

Effects of community succession dynamics on forest biodiversity in eastern mountainous area of Heilongjiang Province

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Abstract: Plant, insect and forest structures of 25 forest communities were investigated in Mao'ershan Experimental Forest Farm and Liangshui Experimental Forest Farm during 1994-1995. The paper used continuum index (C_i) as a parameter, to quantitatively describe forest community succession stage. Relationships between the biodiversity and continuum index of forest community were studied. The annual species and family diversities in forest plant community showed nonlinear correlation with continuum index, and the largest diversities were during the middle stage of succession. The diversities of total insect community and herbivorous insect group were negatively related with C_i , that of spide group and parasitic insect group was positively related. The pattern diversity and coverage weight diversity index foliage height increased with continuum index.

Key words: Diversity; Continuum index; Community dynamics

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Introduction

Any forest communities are in a specified succession stage. If one wants to find out the relationship between succession of forest community and diversity, the key matter is to quantitatively determine its succession sage. This paper uses continuum index (C_i) given by Curtis & McIntosh (1951) as a parameter. The relationship between succession of natural forest community and biodiversity in Mao'ershan Experimental Forest Farm and Liangshui Experimental Forest Farm was studied. The study is aimed at providing theoretical base for conservation of biodiversity and sustainable control of forest pest insects.

Sites and methods

Site description

The experiment was carried out at Mao'ershan Experimental Forest Farm ($127^{\circ}30' E$, $47^{\circ}10'50'' N$) and Liangshui Experimental Forest Farm ($128^{\circ}53'20'' E$, $47^{\circ}10'50'' N$) in Heilongjiang Province. The zonal

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climax vegetation in both areas was broad-leaved pine forest. The plot stands belong to original broad-leaved Korean pine forests in Liangshui area and natural secondary forests in Mao'ershan area, which were in different succession stage.

Data collection

Plant, insect, spied and forest structures of 25 forest communities were investigated in late spring, early summer, late summer and early autumn.

Data analysis

A: Continuum index (Curtis et al. 1951)

$$C_i = \sum_{i=1}^S I_v \cdot C_{AN}$$

Where:

C_i -Continuum index

I_v -Important value of tree

C_{AN} -Climax adaptation number

S -number of species

B: Shannon-wiener diversity index (Magurran et al. 1998)

$$H = - \sum_{i=1}^S P_i \cdot \log P_i$$

Where:

H --Shannon-wiener diversity index

P_i -- Proportion of individual of i th species

S --The number of species of community

C: Pattern diversity index of community (Pielou *et al.* 1966)

$$H'_p = H(n)/E(H(n))$$

Where:

H'_p --Pattern diversity index of community

$$H(n) = 1/n \log n! / n_1! n_2! \cdots n_s!$$

$E(H(n))$ --Expectation of $H(n)$

Where: n is total number of individuals per community; n_i is the number of individuals of i th species in a community; S is the number of species of community

D: Coverage weight diversity index of foliage height (Gao *et al.* 1992)

$$H'_c = \sum_{i=1}^S [(C_i / C) \cdot (H_i / H)] \cdot \ln [(C_i / C) \cdot (H_i / H)]$$

Where:

H'_c --Coverage weight diversity index of foliage height (Gao 1992)

C_i --Coverage of per foliage height

C --Total coverage

H_i -- i th foliage height

H --Height of community

S --The number of species of community

Results

Effect of community succession on plant diversity

Continuum index and diversities of forest communities were given in Table 1.

Table 1. Continuum index and diversities of forest communities (Heilongjiang Province, 1996)

Number of forest community	H'_{ps}	H'_{pf}	H'_p	H'_c	H'_z	H'_{sp}	H'_{j}	H'_{t}	C_i
1	3.06	2.23	0.475	0.755	2.371	1.225	1.173	2.819	3.17
2	3.50	2.84	0.341	1.021	3.183	1.454	0.630	3.477	3.96
3	3.66	2.80	0.537	0.797	3.684	1.572	0.821	3.910	4.89
4	3.31	2.86	0.664	0.910	3.010	1.919	1.232	3.570	4.03
5	3.25	2.77	0.185	0.874	2.900	1.696	1.517	3.450	4.06
6	1.77	1.41	0.000	0.327	3.084	1.424	0.355	3.285	2.80
7	3.35	2.81	0.698	1.083	3.120	1.753	1.080	3.393	4.05
8	3.13	2.77	0.520	0.876	2.620	1.689	1.301	3.186	3.80
9	3.27	2.56	0.304	0.885	2.250	1.740	1.416	3.097	3.12
10	3.30	2.78	0.509	1.002	2.580	1.074	0.927	3.016	4.15
11	3.27	2.63	0.404	1.054	3.144	1.544	0.669	3.489	3.67
12	3.12	2.34	0.113	0.832	2.983	1.345	0.669	3.157	3.02
13	2.65	2.14	0.411	0.921	2.790	1.381	1.211	3.320	3.27
14	3.52	2.78	0.120	1.341	2.650	1.524	1.475	3.220	5.66
15	2.91	2.44	0.515	1.055	2.960	1.563	1.250	3.410	3.21
16	2.86	2.41	0.186	1.258	3.150	1.763	1.525	3.627	3.68
17	2.50	2.29	0.285	1.051	2.884	1.527	1.424	3.370	3.49
18	2.28	1.98	0.285	1.059	3.384	1.498	1.470	3.633	3.13
19	3.28	2.87	0.112	0.358	3.215	2.062	1.709	3.585	4.45
20	3.10	2.50	0.286	0.921	3.299	1.610	1.624	3.638	3.33
21	3.51	2.83	0.432	0.827	2.650	1.750	2.013	3.456	5.07
22	2.80	2.34	0.298	0.884	3.210	1.790	1.917	3.639	2.32
23	2.76	2.44	0.835	1.121	1.995	2.023	1.003	3.176	6.32
24	3.40	2.74	0.879	1.120	2.732	1.673	1.732	3.320	7.32
25	3.22	2.51	0.804	1.164	2.580	2.094	1.595	3.590	6.46

Notes: H'_{ps} --diversity of plant species; H'_{pf} --diversity of plant family; H'_p --plant diversity; H'_c --Coverage weight diversity index of foliage height; H'_z --diversity of herbivorous insect; H'_{sp} --diversity of spide; H'_{j} --diversity of parasitic insect; H'_{t} --diversity of total insect group; C_i --Coverage of per foliage height.

Species and family diversities are low during initial succession stage, but increase fair fast with suc-

cession progress. After they reaches maximum in the middle succession stage, they decrease lightly (Table

1). Regression functions are respectively

$$H'_{Ps}=0.046C_i^4+0.087C_i^3+5.82C_i^2-15.8C_i+17.69(r=0.45);$$

$$H'_{Pr}=0.043C_i^4-0.816C_i^3+5039C_i^2-14.5C_i+15.8(r=0.453).$$

The change tendency of species and family diversity of forest plant communities is similar to the result obtained by Xie Jinyang in North China (Xie et al. 1994). It is difficult to clearly explain the cause, and there is much matter such as the origin of communities, disturbance, the edge influence of time and niche theory etc.

Effect of community succession on insect and spide diversities

The annual species diversities of insect community and herbivorous insect group showed decrease tendency with C_i (Table 1). Regression functions are respectively

$$H'_T=3.55-0.031C_i(r=-0.169),$$

$$H'_z=3.457-0.13C_i(r=-0.48)$$

The diversities of parasitic insect group and spide indicated an increase tendency. Regression functions are respectively

$$H'_{Sp}=1.40+0.057C_i(r=0.342),$$

$$H'_J=1.15+0.035C_i(r=0.128).$$

Compared with the coefficient of parasitic insect group, that of spide is larger. But relationships between C_i and diversity of any insect functional group are not relatively significant, and they only reflect a tendency.

Effect of community succession on structural diversity of plant communities

Pattern diversity is a parameter, which can describe diversity of tree species in a plant community. It can be found from Table 1 that pattern diversity index increases along with C_i , and regression function is

$$H'_p=0.11+0.129C_i(r=0.67).$$

During the initial succession stage, generally speaking, a few pioneer tree species, for example, *Populus davidiana* Dode and *Betula platyphylla* Suk

invade forest land, and are absolutely dominant in communities, possibility in which the individuals of the same species are relatively large. Therefore, pattern diversity is fair low. However, a large number of non-pioneer tree species invade and colonize with succession progress, and the species richness increases possibility are relatively low, pattern diversity increases.

Effect of succession dynamics on vertical structural diversity of plant community

Table 1 shows coverage weight diversity index of foliage height increases with C_i , and regression function is $H'_C=2.234+0.1983C_i(r=0.37)$. The forest plant communities gradually mature with the succession, and hold more species. These make structure of forest plant community more complex and reasonable.

Conclusions

The annual species and family diversity in forest plant community show nonlinear correlation with continuum index (C_i), and diversities are largest in the middle stage of succession.

The diversities of the insect community and herbivorous insect group are negatively related with C_i , that of spide group and parasitic insect group is positively related. The pattern diversity index and coverage weight diversity index of foliage height increase with continuum index.

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